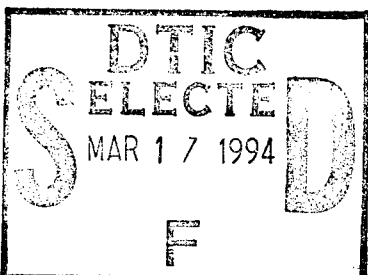


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COMPOSITE MATERIAL STUDIES FOR LOW TEMPERATURE THERMIONIC EMISSION

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May 26, 1994

Summary of Research Results for the Period

May 1, 1992 to December 31, 1993

Prepared for

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SUMMARY OF COMPLETED PROJECT

The primary objectives of this project were to prepare and measure the photoemissive properties of metal-semiconductor inhomogeneous composite systems for use as low temperature thermionic emitters. The system investigated in this study was Au-CuInSe₂ where the Au was in the form of particles 5-50 nm in size dispersed throughout p-type CuInSe₂. Much like oxide-coated cathodes the surface of this composite must be treated in order to reduce the barrier to emission of electrons. If the electron affinity of the semiconductor is made close to zero or negative by appropriate surface treatments one has a system with an electron thermal energy barrier of 1 eV at room temperature (the approximate band gap of CuInSe₂) which is smaller than that of oxide-coated cathodes (typically 1.2 eV) at operating temperatures of 700°C and which produce space-charge limited currents of about 0.5 amps/cm². The advantages of the metal-semiconductor composite over the oxide-coated cathode are two-fold. The composite is highly conductive and is capable of higher current densities at lower temperatures due to the lack of space-charge limited operation. The Au particles which have electron densities of 10²² cm⁻³ which is three orders of magnitude higher than the occupied density of states in the valence band (10¹⁹ cm⁻³) is the source of electrons in the composite system. As the volume fraction of Au is at least 30% a larger source of thermal electrons are available from the composites relative to the oxide-coated cathode. Au-CuInSe₂ composites were prepared with Au particles with a range of particle sizes of 5-10 nm and a volume fraction of approximately 35%. An Cs-O surface treatment was performed resulting in a maximum thermionic current at room temperature of 10⁻⁷ amps/cm² at room temperature and a thermal barrier of 1eV. At 250°C the maximum current of 10⁻² amp/cm² was reached. The current decreased above this temperature which is consistent with the breakdown of cesium suboxide and cesium monoxide at this temperature. Though this current is small relative to the desired current density of 1 amp/cm² is hoped that treatment with barium will produce a stable surface which could be heated to temperatures near 500-600°C yielding current densities close to 1 amps/cm². These results are extremely encouraging at this time.